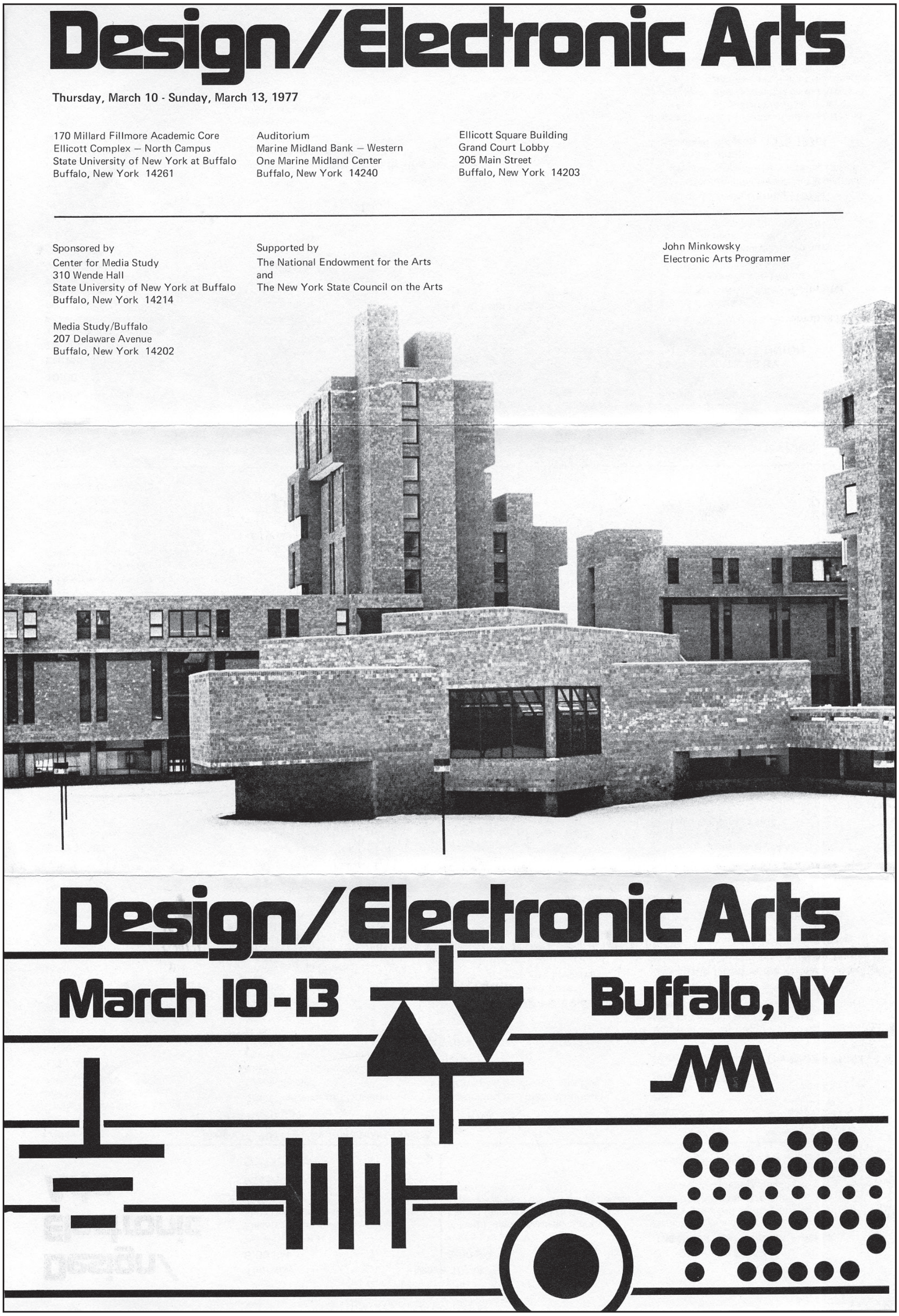
In March 1977, not many months into my tenure as 'Video/Electronic Arts' Curator at Media Study/Buffalo (MS/B), a regional center in Western New York, I was given the opportunity to organize a four-day conference, 'Design/Electronic Arts', to explore the collaboration of video and audio artists and theorists/engineers/technicians/scientists in devising new tools for creative imaging and sound. Two dozen prominent innovators in this field were invited to exchange ideas regarding the principles of design and practical information about it. While suggestions concerning the roster of participants came from many sources, the two most generous advisors were Woody Vasulka and Gerald O'Grady. Nearly all the sessions were conducted in a large auditorium at the Marine Midland Bank in downtown Buffalo. Funding came from the New York State Council on the Arts, the National Endowment for the Arts and the Center for Media Study (CMS) at the State University of New York at Buffalo (as a cosponsor).

I was founding Curator at MS/B from the fall of 1976 through the end of 1984, and organized 300 presentations and performances by videomakers and musicians, as well as touring exhibitions and residencies by artists to create new works and to design audio tools. I came to the position with a substantial awareness of the current trends in both video and electronic music, having arrived as a freshman at the State University of New York in 1971, just as CMS and MS/B were coming into existence. Every week, a different artist working in video was invited to make a screening/presentation at the University, and I attended them all, taking in the full range of video experimentation. I was also fortunate to have Stan Vanderbeek, Ed Emshwiller, Peter Campus and Nam June Paik as some of my earliest instructors in videomaking. Paik, in a short seminar, introduced everyone to the raster distortion of broadcast signals by placing powerful electromagnets atop TV monitors.

Buffalo was, therefore, teeming with electronic media activity by virtue of both the Center for Media Study at the university and the independent Media Study/Buffalo – both founded by Gerald O'Grady – with a particular interest in the development of new tools for electronic art, of which there were perhaps only two other locations in the country (the Experimental Television Center in Binghamton, New York, and the Electronic Visualization Center in Chicago [both well represented at the conference]). Buffalo was also the home of audio-tool designers Robert Moog and Harald Bode, and the computer music pioneer Lejaren Hiller, with whom I had various degrees of interaction. The arrival of Steina and Woody Vasulka to teach at CMS in 1974 proved to be the final key ingredient, for they had been the preeminent innovators in exploring




Figures 1 and 2. Poster for ‘Design/Electronic Arts: The Buffalo Conference’, March 10–13, 1977.

# Design/ Electronic Arts

**Thursday** March 10, 1977

**6:00 PM**
Fargo Dining Hall
Ellicott Complex — North Campus
State University of New York at Buffalo
Buffalo, New York 14261

*RECEPTION*
*By Invitation Only*

**8:00 PM**
Room 170
Millard Fillmore Academic Core
Ellicott Complex — North Campus
State University of New York at Buffalo
Buffalo, New York 14261

**Self-Observing Systems: The Video Revolution in America**
Gene Youngblood
Film & Television Study Center
6233 Hollywood Blvd. at Vine
Hollywood, California 90028

**Open to the Public**

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**Friday** March 11, 1977 **By Invitation Only**

Auditorium
Marine Midland Bank — Western
One Marine Midland Center
Buffalo, New York 14240

**9:30 AM**
Introduction
Gerald O'Grady
Director, Center for Media Study
310 Wende Hall
State University of New York at Buffalo
Buffalo, New York 14214
and
Media Study/Buffalo
207 Delaware Avenue
Buffalo, New York 14202

**10:00 AM**
**Technological Art: Some Problems**
Ken Knowlton
Bell Telephone Laboratories
Room 2C 525
Murray Hill, New Jersey 07974

**11:00 AM**
**The Geometry of Consciousness**
George Chaikin
Brain Research Laboratory
New York Medical College
Flower Fifth Avenue Hospital
at 106th Street
New York, New York 10029

**12 Noon**
**Visible Languages: Towards Diagrammatic Environmental Communications**
Aaron Marcus
School of Architecture and Urban Planning
Princeton University
Princeton, New Jersey 08640

**1:00-3:00 PM**
Lunch

**3:00 PM**
**Designing in Time: Common Principles in Visuals and Sound**
Laurie Spiegel
175 Duane Street
New York, New York 10013

**4:00 PM**
**A Description of the Landscape Within Which Computer Music Systems Are Designed**
Joel Chadabe
Department of Music
State University of New York at Albany
Albany, New York 12222

**5:00 PM**
**Applications of Speech Synthesis to Music**
Joseph Olive
Bell Telephone Laboratories
Murray Hill, New Jersey 07974

**6:00-8:00 PM**
Dinner

**8:00 PM**
**Generative Systems—The Missing Media**
Sonia Sheridan
School of the Art Institute of Chicago
Michigan Avenue and Adams Street
Chicago, Illinois 60603

**9:00 PM**
**Music with Roots in the Aether: Video Portraits of Composers and Their Music**
Selected Short Subjects: (1) Cast and Crew, (2) Manners, (3) Are There Any Questions, (4) There's Always a Scandal, (5) Coming Attractions, (6) Intermission
The Feature: What She Thinks
Robert Ashley
Director
Center for Contemporary Music
Mills College
Oakland, California 94613

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**Saturday** March 12, 1977 **By Invitation Only**

Auditorium
Marine Midland Bank — Western
One Marine Midland Center
Buffalo, New York 14240

**10:00 AM**
**3-D Digitizing and Motion Description**
James H. Clark
Information Sciences
University of California at Santa Cruz
Santa Cruz, California 95064

**11:00 AM**
**A Description of the Anima-II 3-D Color Computer Animation System**
Charles Csuri
Ohio State University
Research Center
1314 Kinnear Road
Columbus, Ohio 43212

**12 Noon**
**Synthavision: An Overview**
Larry Elin
Synthavision
3 Westchester Plaza
Elmsford, New York 10523

**1:00-3:00 PM**
Lunch

**3:00 PM**
**How to Apply What You Know About Analog Electronic Art to Your First Computer**
Tom DeFanti
Department of Chemistry
University of Illinois at Chicago Circle
Box 4348
Chicago, Illinois 60680

**4:00 PM**
**The Image Processor: Design, Operation, Use**
Dan Sandin
Department of Art
University of Illinois at Chicago Circle
Box 4348
Chicago, Illinois 60680

**5:00 PM**
**Crosseye, General Motors — 1976, Re-Scanning of Eve-1 and Eve-88 and Glimpses of Other Entities in Process**
Phil Morton
1839 S. Halstead Street
Chicago, Illinois 60608

**6:00-8:00 PM**
Dinner

**8:00 PM**
**From Slit-Scan to Raster-Scan**
John Whitney
Motion Graphics
600 Erskine Drive
Pacific Palisades, California 90272

**9:00 PM**
**Art and Technology**
Stan Vanderbeek
Department of Art
University of Maryland
Baltimore County
Baltimore, Maryland 21201

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**Sunday** March 13, 1977 **By Invitation Only**

Auditorium
Marine Midland Bank — Western
One Marine Midland Center
Buffalo, New York 14240

**10:00 AM**
**Pantomation**
Tom Dewitt
111 North Pine Avenue
Albany, New York 12203
Phillip Edelstein
Technical Supervisor
Electronic Music Studies
State University of New York at Albany
Albany, New York 12222

**11:00 AM**
**Digital Meets Video: The Best of Both Possible Worlds**
Lou Katz
College of Physicians and Surgeons
Columbia University
630 West 168th Street
New York, New York 10032

**12 Noon**
**Computer Control of Real Time Television Devices and Devices for Micro-Processing**
William Etra
42 E. 23rd Street
New York, New York 10010

**1:00-3:00 PM**
Lunch

**3:00 PM**
**A Computer-Based Video Synthesizer: Part I Hardware**
Don McArthur
Experimental Television Center
164 Court Street
Binghamton, New York 13901

**4:00 PM**
**A Computer-Based Video Synthesizer: Part II Software**
Walter Wright
Experimental Television Center
164 Court Street
Binghamton, New York 13901

**5:00 PM**
**The Territory, The Subject and The Transmission of Knowledge**
Woody Vasulka
Center for Media Study
State University of New York at Buffalo
310 Wende Hall
Buffalo, New York 14214

**6:00-8:00 PM**
Dinner

**Sunday** **Open to the Public**
Ellicott Square Building
Grand Court Lobby
295 Main Street
Buffalo, New York 14203

**8:00 PM**
**PERFORMANCES BY THE SONIC ARTS UNION**

Robert Ashley
**The Great Northern Automobile Presence**

David Behrman
**Music for Cornet, Micro-Computer and Homemade Electronics**
David Behrman - Electronics
Jim Horton - Computer Programmer
Gordon Mumma - Cornet
Kim One - Harmonic Changes

Alvin Lucier
**Bird and Person Dyning (1975)**
For Performer with Microphones, Amplifiers, Loudspeakers and Sound-Producing Object

Gordon Mumma
**Passenger Pidgeon (1676-1976)**

Co-Sponsored by Center of the Creative and Performing Arts, SUNY/Buffalo, The University-Wide Committee on the Arts, and Meet the Composer, a Project of the American Music Center, Funded by The New York State Council on the Arts

the materiality of the electronic media using new instruments designed for personal analytical and expressive purposes.

The particular artist/designers who were invited to the conference were selected from a much longer registry because they brought with them a range of approaches, which were nonetheless interrelated, to each of the categories of work described below. But there were reasons why some were not present as well. For example, Ivan Sutherland told me that he was no longer interested in making such presentations, having done so many in the past. For still others, like Shuya Abe in Tokyo, it would have been prohibitively costly to fly to Buffalo given budget constraints. And still others, however enthusiastic, simply were faced with scheduling conflicts that prevented their attendance. All of the initial negotiations were conducted by telephone, and so no written documentation of these communications is extant, although handwritten lists indicate the gradual winnowing away of prospective speakers and presenters. Still, overall, I was satisfied that we had covered the bases with a convocation of brilliant practitioners that would generate a lively exchange.

My intention at the conference was to bring together representatives of three types: conceptual designers, or philosopher/theorists of art, technology and communications; tool and system designers and builders, or those actively engaged in constructing hardware and software systems to be employed by artists; and designers of images and sounds themselves who made use of these new tools. As might be expected, these were soft distinctions that began to dissolve from the outset. Throughout the conference, there were attempts to identify where tool designers and artists could be distinguished in the collaborative cross-fertilization between these traditionally distinct realms.

The nature of the collaborations between artists and designers could take a number of forms, among them the hardware or software designer creating machines and programs to specifically meet the needs of a particular artist's vision; the artist learning the potentials and limitations of a system from the designer in order to create works based on these criteria, and an open exchange of ideas that could result in image and sound forms unforeseen by those involved, and in the creation of new instruments toward these ends. An artist's desire to affect certain manifestations of her own ideas might prompt the scientist to envision fresh approaches to his own art of post-industrial invention and application.

Here, in Sections 1 – 4, I present the situation vis-à-vis electronic art circa the late 1970s and how it had come to be (1), followed by a list of principles of electronic tool design as enumerated by Dan Sandin for his analog Image Processor (2). There follow summaries of the talks, demonstrations and performances by each of the 24 presenters, and a final address by Woody Vasulka (3). Finally, I offer my brief perspective on the techno-cultural developments in the more than thirty years since the conference (4).

Most quotations are directly from the audiotape records of these proceedings. Those from other sources have been footnoted.

## 1. The state of the art: 1977

It had only been a decade since Sony mass-marketed the portapak, the affordable hardware that initiated the independent video movement in America. That was phase one. The second phase, within a few years, was the move by a handful of artists to invent specialized analog tools – video synthesizers and processors, colorizers, and multi-keyers, among others – that permitted a wide variety of modulation of video signal waveforms in real time to allow vast arrays of 'special effects' beyond those available in the standard television studio.[1] By 1977, video was in its third stage – the transition from analog to digital generation and control of the television signal to further extend the creative use of the medium. It was then that the first home computers appeared for purchase by the general public, based on the microprocessor technology that came as a result of integrated circuits acting as central processing units. The first attempts at interfacing digital and analog – converting digital information back to the analog mode of the television system and vice versa – were, at this stage, often dependent upon the mainframe computer systems available only at large industrial, research and educational facilities that could afford them, although this was rapidly becoming less the case.

This had been the trajectory of video art in its first decade – from a primitive portable straight-on recording instrument, to analog signal-processing tools that were often unpredictable in their behavior, to the beginnings of precision control with digital computers.

While this is a huge simplification of developments during the first decade of video tool exploration, it does point to the fact that 'Design/Electronic Arts' took place at a pivotal moment – the cusp of video taking its next step into uncharted territory. And it is essential to reiterate that the transition from analog to digital was very much a new direction in tool making that would have enormous impact on all that came after in the electronic arts.

## 2. Some principles of tool design

Throughout the conference, as designers outlined some of the principles upon which they already worked in the hardware and software they were developing, the two most operative words were 'real time' and 'interactive'. No one articulated his own criteria with such specificity as Dan Sandin in describing his design of the analog Image Processor (IP). I present Sandin's list as an expedient template in considering the many ideas that were later recapitulated by others in different ways. Although Sandin focused on his analog IP at the time of the conference, most of the design ideals he expressed would extend to its digital counterpart already under way.

*Real time*: 'Analog systems are so dumb they can't store any information,' said Sandin, 'so the stuff's got to come out as fast as it goes in. It is an inherently real-time system in most cases, especially with video' (Sandin and Morton 1977).

This was not the case with digital tools, where storage capacity of signal data was to a large degree fundamental to the ways they were to be employed. The particularities of the

hardware itself and complexities of the software programming could create delays between one end and the other, or determine the durational parameters of the act of creation based upon the time required to compute a single image frame. There was, at the beginning at least, a trade-off between analog spontaneity and digital control. But it was not an either/or situation: some systems permitted both modes of real-time decision making and more contemplative modes of composition, the scores of which could be retrieved immediately upon completion of a work for evaluation and revision.

*Interactive*: Interactivity is part and parcel with real-time systems, and it became more a question of degree and type; for example, how easily the user could make the cognitive connection between her actions and the images or sounds produced, and to what extent repeatability of a particular visual/aural event was possible.

*Rich feedback*: The immediate gratification of witnessing the results of one's actions is closely linked with real-time interactivity. Optimally, thought Sandin, feedback should be as rich in character and detail as possible.

*General purpose*: Systems should be general purpose, ones in which the logical organization or architecture would not present 'walls' (limits of flexibility) to the user. These were opposed to special-purpose turnkey tools – one-trick black boxes which performed with the flip of a switch – that limited what Sandin termed 'modes of thought' encouraged by more generalized flexibility.

*Modularity*: A key factor here was constructing the machine out of discrete units capable of particular input-to-output processing that a user could easily interconnect to generate images of enormously diverse natures. Modular systems could reproduce functions of the special effects console as well as many more radical visual manipulations. And the interchangeability of voltage controls and image allowed one image to affect another. Furthermore, the neophyte could first master the small domain of this array of modules to simulate a special purpose piece of hardware, and then begin to combine it with others to discover new complexities as his sense of competence increased.

*Easy to learn*: Admittedly, Sandin noted, general-purpose systems often contravene ease of learning. Digital computers, which are always general purpose, require that the user could proceed only with a substantial body of knowledge, such as complex assembly languages, rules of programming, and the generation of subroutines. But here, Sandin thought, the tension between too many and too few options could be mitigated by finding 'a slice through these two worlds that gives you a tremendous amount of generality and still maintains a conceptual clarity or kind of hierarchy that allows one to start knowing very little, with the machine teaching the rest' (Sandin and Morton 1977).

*High tactility*: This was one means of easing new users into the system, a manner of developing a direct relationship between what the hand does and what the eye sees. The IP used patch programming – something like a superannuated telephone switchboard – to plug together modules in as simple or labyrinthine manner as desired, but other peripherals like joysticks were also employed. Working at 'touchie-feelie' inputs of this

sort obviously constituted a different process than typing elaborate instructions at a computer keyboard to obtain results.

*Portability*: Portability is a relative term. Although cumbersome, the IP could be packed and transported to other sites for performances, and this was a common *modus operandi* of Sandin's compatriot Phil Morton to create his two-way interactive installations. Mobility of other large systems was clearly impossible, and even Don McArthur, who aspired to portability with his Computer-Based Video Synthesizer, had up to that point only created hardware roughly comparable in size to two refrigerators.

*Low cost*: Putting a tool in the hands of as many individuals as possible to explore at their own pace was one of Sandin's primary objectives, and he provided the schematics gratis to anyone who wished to construct her own IP at an estimated cost of $3000. Compare this figure with the $10 million machine available at Columbia University and the discrepancy is breathtaking. But, as many noted, the home computer would bring digital tools out of the institution and directly into the hands of artists.

*Issues of safety*: An assurance that, in their interaction, neither was the user hurt nor the tool damaged was a design consideration for Sandin, and it is not an irrelevant one when speaking of intimate and extended hands-on employment of a complex electronic instrument. Stephen Beck, the designer of the Direct Video Synthesizer at the National Center for Experiments in Television in San Francisco, never let anyone else use his machine for fear that they might cause damage that would require countless hours to diagnose and repair.

These, then, were some of Dan Sandin's criteria for an ideal electronic imaging tool.[2] In what follows, the manner in which other designer/artists shared them and envisioned additional ones will become clear.

## 3. Presentations at the 'Design/Electronic Arts' conference

Placing Sandin's criteria in a proper context requires a description of the conference proceedings and participants. They are here categorized under 'Theory', 'Music', '3D motion graphics', 'Graphic arts' and 'Design by collaborative teams for computer-based video systems', as well as 'Evening events: presentations, a mini-retrospective and a concert', and Woody Vasulka's summary comments.

### Theory

By theory I mean that which offers conceptual models that are projective, prescriptive, or analytic, or otherwise describe unusual and original systemic paradigms, and three presentations – those by Gene Youngblood, Ken Knowlton and George Chaikin – fell within this category.

Gene Youngblood's keynote lecture, 'Self-Observing Systems: The Video Revolution in America', took place at the Ellicott Complex at the North Campus of SUNY/Buffalo. Author of the influential 1970 book, *Expanded Cinema*, he eschewed his earlier focus on specific tools to speak more generally about the need for a large-scale restructuring of the mass communications system from centralized one-way distribution to consumers to a specialized two-way, point-to-point, user-controlled feedback system.

This was to be a revolution through the total inversion of the structural and functional organization of the mass media, replacing 'the processing of centralized output with processing of decentralized input as the chief characteristic of the medium' (Youngblood 1977), giving the public access to information specified by the user through channels controlled individually. There was at present no mass communication, only mass distribution. Its reorganization would constitute the first true communications revolution in history – the invention of movable type excepted – rather than a mere series of technological innovations.

Youngblood tied the effect of the mass media to human evolution. Influenced by the writings of the Chilean biologist and cognitive scientist Humberto Maturana, his underlying premise was that there appeared to be no grounds for human unity in social modes of thinking and organization other than the desire for it, and that the mass media, by offering only one monolithic version of reality, served to attenuate the passive receiver's ability to imagine others. The interactions of two or more people engaged in communication are requisite to formulating models of what can and should be new structures for talking, thinking, and actualizing their own internal representations of reality. The goal of Youngblood's proposed model was to be achieved with newly (or soon to be) available technologies.[3]

Ken Knowlton offered something like a second keynote address the following morning in 'Technological Art: Some Problems'. Knowlton worked for many years at Bell Laboratories in Murray Hill, New Jersey, designing and implementing software for computer graphics and films, most notably the programming language BEFLIX (Bell Flicks), the first bitmap movie-making system. With his collaboration, these were made available to artists like Stan Vanderbeek, Lillian Schwartz and Laurie Spiegel. Knowlton is also a recognized artist in his own right.[4]

Knowlton used the occasion of 'Design/Electronic Arts' to raise three questions about art as it was coming to pass in the always-morphing environment of new technologies, and the manner in which these technologies should be employed and presented to novices. The first issue was the degree to which the artist should explain the ways in which a work was created, that is, the equipment and processes themselves and how they were used, rather than the particular aesthetic decisions made from a landscape of possibilities. The second was whether collaboration was desirable or more a matter of necessity, given the types of technical knowledge required that might otherwise keep artists at bay. And finally, there was the question, as he put it, of whether one should take 'big steps or little steps in defining new media' (Knowlton 1977), the first ostensibly creating a baffling and alienating hurdle

for those who encountered challenging works, and the last representing a set of incremental transformations that would connect new forms with those that came before.

Knowlton's ruminations can be summed up as follows: how to use technology without letting it interfere with the perception of the role of the artist who employs it; and how to initiate a new generation of viewers/auditors into these radical forms in some measured manner.

George Chaikin of the Brain Research Laboratory at the New York Medical College, in a presentation entitled 'The Geometry of Consciousness', proposed a model of visual encoding based on logarithmic spirals – such as one might find in the nautilus shell and the architectural design of the Parthenon – rather than linear logarithms. He speculated that this new model would more closely resemble the way the eye functions, a fact, he said, recently verified by scientific studies. A machine retina could be made not only to be more fully representative of human optical systems, but also to allow for more rapid computation of electronic images, and he had simulated an elementary version of a hypothetical camera that would scan in this manner. This intriguing concept had resonance beyond the manufacture of concrete instrumentation for art to that of the nature of human perception itself.

## Music

The development of electronic audio tools long predates that of visual systems. The first is generally considered to be Dr Thaddeus Cahill's Telharmonium (1897), but it was Lee DeForest's invention of the first vacuum tube in 1906 – which would also lead to radio broadcasting and early computers – that spurred a great deal of instrument making for audio signal processing in the 1920s. The most famous of these is the Theremin (1919) by the Russian inventor Leo Theremin. Many prominent composers like Edgar Varèse and Darius Milhaud employed this and other early analog instruments. In the early 1960s, Don Buchla introduced the Buchla Box, and Robert Moog created his commercial audio synthesizer, the Moog. Both were modular in design and used the transformation of tone-generated signals in an additive and subtractive manner to alter pitch, tone and other aspects, and could be played live. These early analog synthesizers were models to a large extent for those who later embarked on building video synthesizers.

In the meantime, digital computer music was also making headway, with systems being developed by Max Mathews at Bell Labs and others in the 1950s, and explored at the Electronic Music Studio at the University of Illinois at Urbana-Champaign founded by Lejaren Hiller, and the Columbia-Princeton Electronic Music Center by Otto Luening, Vladimir Ussachevsky, Milton Babbitt and Roger Sessions. Like many digital video explorations two decades later, these were reliant on large mainframe systems, and most primarily focused on the use of the computer as a compositional rather than performance tool.

One afternoon of the conference was devoted to the most recent developments in computer music by Laurie Spiegel, Joel Chadabe and Joseph Olive.

Laurie Spiegel, a highly respected composer/performer as well as designer of tools for computer music,[5] also worked in the mid-1970s at Bell Laboratories. There, she began to experiment with computer video graphics, using a Rand Tablet and FORTRAN IV software program she'd written for drawing directly onto a display screen, and VAMPIRE (Video and Music Program for Interactive Realtime Explorations). Her talk, 'Designing in Time: Common Principles in Visuals and Sounds', covered the ways in which she interfaced visual composing with the time-structuring software she was already using for music compositions, and the similarities and differences of working in both of these forms.

Joel Chadabe, a Professor of Music and founder of the electronic music studio at the State University of New York at Albany, presented 'A Description of the Landscape Within Which Computer Music Systems Are Designed', which was later published in the *Computer Music Journal*. Chadabe had been a pioneer in the development of real-time interactive systems, attempting to bring the level of feedback of the visual arts to music, and here he spoke broadly about the organizational design of systems that incorporated the digital computer as an important element, either as performer or composer-performer. He used the term 'memory automation' to signify the computer's capacity for storing a score and playing it back for the composer who could then interactively 'conduct' the work. He distinguished this from 'process automation', whereby computer-generated data was based on rules specified by the composer, who was then free to make selections from the outputted sequences. But it was toward the simultaneous composition and perception that Chadabe had concentrated his greatest focus, a procedure that allowed for constant evaluation and flexible redefinition of rhythm, speed, articulation and other details of the music as they were being generated.

Joseph Olive, also a researcher at Bell Laboratories, spoke on 'Applications of Speech Synthesis to Music'. After a brief overview of centuries-old endeavors to simulate human speech by artificial means, he explained the use of spectrographic analysis in attempts to emulate resonances and the like by means of computer software that dominated his text-to-speech synthesis research. His interactive programming was able to alter the time axis, the pitch contour and the sound spectrum. Examples of all of these experiments were interspersed throughout, but the talk culminated with an excerpt from his own opera, *MA-RI-IA-A*, its humorous libretto an enactment of a scientist teaching his machine to talk.

## 3D motion graphics

In 1977, 3D motion graphics systems, now so commonplace, were in their infancy, with the largest developmental support coming from investors outside the art world. The ability to create only 2D imagery for the video screen was now being extended to manifest representations of synthetic worlds along three axes, a capacity that would have

a profound effect not only in industrial, scientific and entertainment endeavors, but those of artists as well.

Therefore, one morning session was dedicated to three-dimensional computer animation systems, or what Charles Csuri referred to as 'visible surface calculation', for motion graphics. The focus was simulation of naturalistic objects and environments for a variety of applications in science, industry and art, and the presenters were James H. Clark, Charles Csuri and Larry Elin.

James H. Clark of the Information Sciences Department at the University of California at Santa Cruz ('3D Digitizing and Motion Description') had been involved in tri-dimensional interactive systems, computer-aided design and geometric modeling since he was a graduate student at the University of Utah. There, he had worked with the legendary Ivan Sutherland, who, among his many other accomplishments, created the first Virtual Reality (VR) system that simulated a 3D environment through which the user could navigate. In 1977, Clark described a system he was developing for NASA that would generate a mathematical model of a wind tunnel to analyze potential flaws in the design of aircraft in real time, and had undertaken the creation of a more sophisticated VR head-mounted display.

Charles Csuri was a Professor of Art and the founder of the Computer Graphics Research Group at Ohio State University. He came from a traditional painting and drawing background, but discovered that programming line plotters could offer a vast array of variations on a theme – again many more than he could have envisioned – through both calculated parameters and random-generated sequences, and created the 1967 film *Hummingbird* based upon them.

At Ohio State University, he was developing the ANIMA II system with artists in mind. Essential design aspects were the use of a script language, or what he called 'scene directives', the use of joysticks for fine-tuning the positioning of an object, and a system of orientation notations that appeared on-screen to assist the user in how to proceed. Defining figures was achieved by combining simple geometric objects that Csuri likened to sculpting, which were then subjected to transformation routines to enact scaling, movement and rotation. Numerous other routines refined this shaping of entities, including the warping and bending of specific planes to enhance naturalistic representation. For the most part, real-time interaction was again considered the key to the successful results of ANIMA II.[6]

Larry Elin came from neither the academic nor the art world, but was, rather, a filmmaker/producer for the Mathematical Applications Group, Inc. (MAGI) in Elmsford, New York – one of the breakout companies for the simulation of three-dimensional solid objects in motion for film and television, using its digital animation process, Synthavision. Much of Elin's work in 1977, as exemplified by his sample reels, was created to assist in the design and application of industrial, military and scientific systems, but there was also a smattering of entertainment-related excerpts that would prove to be precursors for what several years later would be MAGI's most visible project – the production of sequences for the 1981 feature film, *TRON* (dir. Steven Lisberger).

His talk defined the three elements an animator using Synthavision had to address: creating the 3D object shape through a process like Csuri's, here called 'Combinatorial Geometry'; defining an imaginary camera with a location, lens and direction from which to view this synthetic object; and determining a light source by which the scene was to be illuminated. The last of many subsequent stages involved recording each frame of the calculated animation onto film stock. Clearly, this was not a real-time system in any sense, and the results had a 'cartoony' feel that would serve it well when a fellow MAGI employee, Jon Lasseter, cofounded Pixar Studios.

## Graphic arts

Aaron Marcus and Sonia Sheridan gave talks on the use of new technologies for the graphic arts – from computer-assisted design to the aesthetic applications of xerographic systems.

Aaron Marcus was a designer and computer and conceptual artist from the School of Architecture and Urban Planning at Princeton University. His work was in 'Visible Languages', a term he used to describe calligraphic and typographical signs, drawings and markings as a 'useful tool for examining systematic aspects of diagrammatic compositions of iconic and symbolic forms' (Marcus 1977). During a period in residence at Bell Labs, he developed a 'prototypical, interactive, computer-assisted page design system' (Marcus 1977), which permitted the flexible electronic arrangement and manipulation of signs and symbols on the surface of a cathode ray tube. Many of the elegant works Marcus projected bore resemblance to concrete poetry, where the relationships of figure to field, geometrical components and other formal properties became aspects of expressive alphabetically-based art.

Most pertinent to the general conceit of the conference were slides from his dynamic series *Cybernetic Landscapes*, virtual realities of a sort that he described as 'poem-drawing environments'. These were highly interactive systems whereby the viewer, by means of joysticks, was able to travel through a dark landscape upon which had been designated signs, symbols, letter forms, objects and other graphic elements rendered as pure-white line drawings.

Sonia Sheridan was the creator of the Generative Systems Program at the University of Illinois at Chicago Circle Campus, a remarkable facility that functioned as a research center for student artists of what she referred to as 'The Missing Media' between video and computers; as a place that wedded earlier methods of art making, such as drawing, photography and textile design, to new electronic technologies; as an interactive force between industry, education and the public; and, perhaps, most importantly, as an attitude and process that extended beyond the use of any specific machine: 'It attempts to reverse the order of motion, from machines remain, to humans remain while machines move' (Sheridan 1975: 6–10).

Sheridan's work focused on Electronic Systems Printout (ESP) using a variety of industrial copying equipment tools such as 3M's Color-in-Color machines, Xerox copiers, and other means of thermographic and electrostatic reproduction. Rather than the more conventional relationship between artist and industrial scientist/technician – where the latter might serve largely as instructor of the machines of the former – Generative Systems often gave back new methods in which these complex pieces of technology could be differently employed: '[I]ndustry has a backlog of 50 years of inventions for which they are looking for new uses, applications and markets. The artist who has access to these inventions is well equipped to dream of alternative inventions and applications' (Sheridan 1975: 6–10). Concomitant with that approach was the recognition that scientists were as creative in their activities as artists, albeit with different aims in mind.

That the systems were interactive and largely in real time was extremely important to this approach as innovative ways to engage them. In this, the thrust of Generative Systems was not unlike the attempts of video and computer artists to provide rich feedback to the creative user.[7]

## Design by collaborative teams for computer-based video systems

The portion of the conference most plentifully represented was that of close collaborations by small cadres of artists/engineers to realize hybrid analog/digital video synthesis tools in Chicago, Albany, New York City and Binghamton. This model was, without question, the most productive of any, and that which demonstrated an ideal for design in the electronic arts.

### 3.1. The Chicago Group – Dan Sandin, Tom DeFanti and Phil Morton

Dan Sandin, Tom DeFanti and Phil Morton created the Electronic Visualization Center, and referred to it as a 'habitat' – a felicitous term signifying an environment in which one could work for indefinite periods of time, continuously learning new ways to yoke the system to her or his own creative ends.

Dan Sandin of the Art Institute of Chicago, then just undertaking the digital version of his analog Image Processor, reviewed the design principles that had gone into it, and these have been described above. One further quote makes yet another salient point:

> I designed the IMAGE PROCESSOR from the point of view of, what does the student have to do to use it? [N]ot from, what can the machine do? [W]ith electronic visualization done properly, the feedback is no longer the *limit*; the limit then becomes how fast your mind can process information; and that is a *much higher limit*, in some cases, especially when processing visual information. (Sandin and Morton 1977)

In Tom DeFanti of the Department of Chemistry at the University of Illinois at Chicago Circle Campus, a formidable computer software designer, Sandin found a kindred spirit with whom to collaborate. DeFanti's GRASS (GRAphics Symbiosis System) became the basis of interfacing with Sandin's analog processor, and DeFanti said that he almost thought of GRASS as an analog system, in that it allowed him and Dan to appropriate real power to accomplish a great deal in short order. He also was a firm believer in high levels of interactivity – to make the system so unsophisticated that it could operate in real time – and in tactility, with large knobs and other paraphernalia. Digital-to-analog conversion made Sandin's analog IP and DeFanti's GRASS software entirely compatible.

Phil Morton, also of the Art Institute of Chicago, was one of the primary users of Sandin's and DeFanti's system, and took it in directions that were distinctly his own. A keen advocate of Citizens' Band radio in particular as a model adaptable to video, he was deeply engaged in the whole topic of telecommunications in general.

Morton forayed into the realm of interactive communications by way of high performance two-way video and audio 'transmission' installations. These were modest (but doable) in scope compared with Youngblood's convulsive model. The typical staging of a Two-Way Communication System consisted of three basic components: (1) an observation area for contemplating the ongoing process and resultant product; (2) two public user terminals, each consisting of a video camera and microphone trained on the other to send information with a monitor and headphones to receive signals from the other site, and tactile devices allowing modification of the focus, angle, intensity and scale of the camera coming from the opposite terminal; and (3) a processing area, where one person (termed the CO-OPERATOR) mixed the camera outputs into a single recordable channel, a second performed on an Arp music synthesizer (the ARPIST), and a third processed the images through Sandin's tool (the IPIST).

### 3.2. Tom DeWitt and Philip Edelstein: Pantomation

Film and videomaker Tom DeWitt and electronics designer Philip Edelstein from the Electronic Music Studio at SUNY Albany made a joint presentation about a new multipurpose tool they had devised, The Electronic Pantograph, which had applications in music, dance and other temporal arts. Edelstein, with others, was responsible for the basic hardware, The Key Positioner, and the specific application by which the process was designated – pantomime – the particular interest of DeWitt. The Pantograph, DeWitt noted, 'uses the eye of a television camera and the brain of a computer to keep track of moving points in space and writes a record of this movement in the abstract language of a computer-choreographer' (DeWitt 1977). It was a graphic notational system of body movements, in particular, achieved by attaching a yellow spot to the performer that was followed by a camera employing chroma key techniques. The computer component provided additional flexibility through its control language, such as, according to Edelstein, 'keeping an object in a fixed position in a video frame although it was originally moving in the real world'

(Edelstein 1977), as well as retracing the described movement by storage of horizontal and vertical components in computer memory. Excerpts of the first use of the Electronic Pantograph, DeWitt's comic sci-fi pantomime, *Outta Space*, demonstrated this process.

### 3.3. Lou Katz and William Etra

Lou Katz was working at the College of Physicians and Surgeons at Columbia University making 3D models of scientific objects when he developed an interest in using its large computer to create aesthetic entities as well. As this work developed, he began to consider rules by which to create images of greater symmetry and complexity that could be changed for the purpose of experimentation and further be preplanned and controlled for repeatability.

At this point, he became acquainted with the artist William Etra who, with the designer Steve Rutt, had created one of the earliest video processors, one which operated on very different principles than did other analog synthesizers of the time. Katz took notice of the possibilities of working with video, and he and Etra began to collaborate on developing a computer-controlled video system. This included finding the means to convert terminal displays and feed them into synthesizers and other effects tools. Like Sandin, Katz also began to make voltage and image signals interchangeable, so that one picture element could be used to control another.

Etra was introduced to lightweight portable video equipment as a film student at New York University and, after having been exposed by Walter Wright to Scanimate, a commercial analog synthesizer, he teamed with engineer Steven Rutt to construct the above-mentioned Scan Processor. While working in an electronic music lab, Etra became convinced that computers constituted the next step, and several years later acquired his own microprocessor. One of the attractive uses of the computer, he noted, was as a notational tool for greater control and repeatability, and the viability of new types of peripheral devices.

### 3.4. Donald McArthur and Walter Wright: A Computer-Based Video Synthesizer

The penultimate session consisted of a two-part presentation by Donald McArthur and Walter Wright about the construction of 'A Computer-Based Video Synthesizer' at the Experimental Television Center (ETC) in Binghamton, New York. McArthur designed the hardware – aka the Spatial and Intensity Digitizer (SAID) – and Walter Wright was responsible for the software for system operation.

McArthur's background was in theoretical physics, and while teaching at the State University of New York at Cortland he became acquainted with the work of the ETC. In 1975, he and Wright initiated the computer-controlled video system, based on the use of a microcomputer interfaced with McArthur's own self-designed digital-to-analog conversion circuitry to provide a NTSC video signal that could be controlled in real time, used for live performance, and recorded on standard videotape recorders.

Rather than paraphrase McArthur's comments at the conference, it is better to quote him at some length describing the functions of the SAID architecture from a paper written in June 1977, functions that bear resemblance to Joel Chadabe's own design concepts:

> There are basically two modes of operation of the system: interactive-compositional mode and automatic-production mode. In the compositional mode, the artist can enter programs and parameters through the keyboard, observe the resulting sequence of images, and then modify parameters through either keyboard or a real-time input and thus build up a data set for a complete piece. The data set, representing all the aesthetic decisions made by the artist, is stored in the computer at each stage of the composition. When the composition is finished the system will operate in the automatic-production mode generating the final video signal in real time with no intervention by the artist. The artist may also choose to use a combination of these two modes in an interactive performance or to allow an audience to interact with the system operating automatically. The system is structured so that all of these variations can be accommodated by appropriate programming. (McArthur 1977)

McArthur spoke further of some of the design principles that went into the construction of this complex system consonant with those expressed by others, including that it be based on a general-purpose machine operating in real time – modular, hybrid and portable.

Walter Wright's talk served as complement to McArthur's presentation, approaching software programming to establish his working relationship with the microcomputer and video synthesizer. Being an artist foremost, he began with the end product – the image – and basic rules of composition that needed to be considered. Wright also extended feedback beyond the interaction between the artist and image to include that between synthesizer and computer, achieved by factors like predictable unpredictability, conditional (if/then) branching, and setting the computer to reprogram itself under certain conditions. This creative programming made the Computer-Based Video Synthesizer a very versatile tool with the potential for all manner of production, presentation and storage.

## Evening events: presentations, a mini-retrospective and a concert

After long days of fervent interchange, evenings were given over to more palliative presentations. Composer Robert Ashley showed excerpts from his recently completed series of unconventional video portraits of his peers entitled *Music With Roots in the Aether* (1976). John Whitney, the dean of new technologies as inventor and artist employing systems for abstract animation, was scheduled to give a talk entitled 'From Raster Scan to Slit-Scan'. In its stead, he concentrated on his most recent work, the stunning *Arabesque* (1975), which was the first film that he made using digital rather than self-designed analog equipment, and is a complex seven-section fluid weave of intricate curvilinear patterns composed of a 360-point array in constant movement. Whitney offered a close reading on an analyzer film

projector of the harmonic principles, akin to those found in music, that underlie its structure. This represented his most current concern with the periodic organization of perceptual experience, and a fully illustrated essay in the same vein, along with a broader look at his career development, can be found in his indispensable book, *Digital Harmony* (1980).

Immediately following Whitney, Stan Vanderbeek presented a mini-retrospective of his work over the previous two decades, beginning with camera-less and cut-out animation films that began his career, through his computer work with Ken Knowlton creating a series of *Poemfields* at Bell Laboratories, and beyond. He also discussed a number of other innovative projects he had undertaken, including projection of film images onto steam, and eight-hour night-long *Cine-Dreams* staged in a planetarium, where viewers were encouraged to drift in and out of sleep to a barrage of images projected on the dome, and later report their oneiric experiences by telephone. Vanderbeek specifically referred to the planetarium as a 'tool', and made use of its unique imaging systems in addition to his own work.[8]

On the final evening, the members of the Sonic Arts Union – Ashley, David Behrman, Alvin Lucier and Gordon Mumma – each performed one of their musical compositions in the Grand Court Lobby of the nearby Ellicott Square Building. Their relevance to the concerns of the conference is best indicated by the title of Behrman's piece, *Music for Cornet, Micro-Computer and Homemade Electronics*, which credits as performers Jim Horton on computer programming and Kim One, his microcomputer, on harmonic changes.

## Woody Vasulka: a summary talk

It fell to artist Woody Vasulka, a professor at the Center for Media Study, SUNY Buffalo, to provide final observations and an open exchange with the audience on the ideas expounded throughout the conference. He prefaced this discussion with his own conception of what he called 'The Territory, The Subject, and the Transmission of Knowledge'.

His notion of 'The Territory' was that of placing development of new artists' tools in the context of a particular era and certain contemporaneous technological innovations. In looking at 'The Subject', he proposed that new concepts arose in electronic imaging that differed substantially from those of photography and cinema. This subject was that which comprised the electronic image as a time-energy construct, such as waveforms and control signals. Vasulka's own personal proclivity was apparent here, as an investigation of the primary elements of the video image (or, as Walter Wright had put it, finding out 'what makes TV tick') had dominated his work from the outset, and he had often referred to his own activities as dialogues with tools, an attempt to understand them and what they revealed about the medium.

Regarding 'The Transmission of Knowledge', he strongly promoted greater dialogue between individuals in transferring of information on hardware and software. Not only was there secrecy in the military-industrial complex, as one example, but also, in what seemed a misplaced implication, between members of the 'tribe' – his term for the very sorts of

participants involved in this four-day conference – who seemed to have been engaged in nothing so much as information interchange.

After his quasi-polemic, Vasulka opened the floor for an extended period of discussion in which a plenum of subjects were touched upon, among them: that an artist reflects who he or she is irrespective of the system employed; whether too much emphasis has been placed on innovation and that the idea of being first diminished the importance of being best; and whether the system and program, as well as the resultant image/sound, were, in fact, a work of art.

## 4. The subsequent years, 1977–2010: some thoughts

As noted above, there were some pragmatic reasons to distinguish between artist and engineer in the electronic arts in the late 1960s and 1970s – the complex technical knowledge necessary to write software for institutionally based computers, and access to artists from those working within these facilities being the two most prominent. But a number of these engineers saw themselves as artists as well, and established makers were already conversant with software design and how it could be applied to their desired ends – this too was part of their creative process. The question raised by some conference attendees as to whether the design of hardware and software systems could themselves be considered an art form clearly depended on how broadly or narrowly one wished to define 'art'. Perhaps this convergence of both roles is best summed up in the following quote by Andy Hertzfield of MIT's Media Lab:

> It's the only job I can think of where I get to be both an engineer and an artist. There's an incredible, rigorous technical element to it, which I like because you have to do very precise thinking. On the other hand, it has a wildly creative side where the boundaries of imagination are the only real limitation. […] It takes incredible concentration and mind space. (Brand 1987: 58)

In the more than three decades since, an entirely new information techno-culture has evolved that has made the kinds of capabilities envisioned in 1977 so pervasive as to be commonplace to a new generation weaned on digital technology – including emerging artists.

It would be an exaggeration to say that analog technology has become obsolete – but only by a fraction. Although there are still pockets of artists making use of analog tools here and there, in the larger context conventional television has been broadcast solely digitally throughout the United States since the middle of 2009. That DTV may in fact cause some degradation in image quality and color distortion is largely overlooked – much as had been the case with the transfer of analog to digital audio, except among true aficionados.

Personal computing devices of many degrees of portability and versatility have, of course, become ubiquitous – perhaps even more so than TV sets themselves. Software packages for computer graphics are often part and parcel with these devices and otherwise stock shelves. Some of the techniques artists were struggling to obtain in 1977 can be

readily learned in coursework at art schools and other institutions. And, needless to say, 3D computer animation of all sorts is inescapable.

And then there is the rise of the Internet – Sir Tim Berners-Lee's World Wide Web – the apotheosis of a true communications revolution as defined by Gene Youngblood. No one in 1977 could have envisioned this phenomenon, but in the words of the great performance artist Yogi Berra: 'It's tough making predictions, especially about the future'.[9]

The new form of Internet art (or net art)[10] developed in the mid-1990s, but the extent to which this phenomenon has been of great moment except to the relatively few cognoscenti is difficult to gauge, and what sorts of work it will produce in the future remain to be seen. A notable contribution has been made, surprisingly, by the website YouTube, which has created a new outlet for the distribution of video art. Virtually every artist who appeared at the conference has works deposited there for viewing in an easy-to-access format.

This is not the place, nor is it my intention to make any sweeping comments about the current state of electronic art. Certainly a great deal of video appears in galleries and museums, and has become wholly integrated into mixed-media installations and performances of all sorts, as a result, in part, of high-quality digital cameras and projection systems. The art world has accommodated and even embraced video as it had earlier ghettoized it.

At first consideration, it seems that less of the kinds of expression we once identified as electronic art – e.g., video synthesis and image processing – has made the transition into the present. But I would qualify this by the reflection that work of this nature was always a subgenre of video in general; many, if not the preponderance, of early tapes and installations evolved around the conceptual and minimalist art movements that often employed apparatus little more sophisticated than ½" monochrome recording equipment. The apparent dearth of electronic video may also have much to do with a general trend away from abstraction and the fact that the novelty of video synthesis has waned over time.

Finally, has anything been lost in the retirement of analog image-processing tools? From my own perspective, gone is some degree of idiosyncratic charm or personality that we associate with handicraft and folk art, by way of machines that reflected in their design and use the human touch that may be missing from many of today's far more sophisticated systems. But the trade-off so substantially favors current technology in other respects as to make this sentiment largely irrelevant. Unearthed artifacts of the Stone Age tell us much about the nature of the progress of civilization, but hardly inspire nostalgia for a lost innocence and quality of life prior to the development of new industrial and post-industrial tools. To the extent that this essay has been an archaeological enterprise of a sort, the conference participants it documents were continuously striving for the new tools that would constitute the next step in transforming aesthetic culture.

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## Notes

1. There had been a longer tradition of the development of electronic music synthesizers. Those most recent and influential had been Don Buchla's Buchla Box (1963) and the first Moog Synthesizer (1964), both of which provided models for the design of the early video synthesizers. An excellent source for information about early visual and sound tools is *Eigenwelt der Apparate-Welt: Pioneers of Electronic Art* from 'Ars Electronica', 1992, an exhibition curated by Woody and Steina Vasulka.
2. It is interesting to compare Sandin's list of desired design principles with those articulated for the industrial computer put forward in 1962 by Claude F. Shannon in his lecture, 'Computers and Automation – Progress and Promise in the Twentieth Century': 'The next generation of computers will be faster, smaller, with greater flexibility and memory capacity, and more reliable. We expect the programming to progress so that it becomes easier to communicate with computers using our own language or something close to it' (Shannon 1962).
3. Another, albeit unusual, reflection of technological innovation and its suppression, as well as biological evolution in this context, can be found in William S. Burroughs's hallucinatory novel, *The Place of Dead Roads* (1983: 215–17). See also *Electronic Revolution* (Burroughs 1971/76: 21–31).
4. See http://www.kenknowlton.com/.
5. See Laurie Spiegel's website, http://retiary.org//ls for extensive information about her software design for digital arts, as well as her music and other activities.
6. In 1977, Csuri's system had been in development for only a few years and was still developing new features. A more comprehensive expression of the artist's ideas, circa 1975, is available at http://www.atariarchives.org/artist/sec25.php.
7. The specific applications that Sheridan and her students employed are too numerous to list here, but an archive of her work has been preserved at The Daniel Langlois Foundation for Art, Science and Technology (La fondation Langlois) in Quebec, Montreal.
8. A somewhat fuller description of Vanderbeek's first *Cine-Dreams* event at the Strasenburgh Planetarium in Rochester, NY in 1972, which I attended, was published in *WNET News*, 1: 3, and it quotes Stan as saying that dreams are 'a rehearsal for the future. Cronkite, instead of reporting the weather, may one day report that 3,000 people dreamed of earthquakes last night'.
9. Claude Shannon, again, spoke in more concrete terms about the pitfalls of predicting future developments, also in the Rice lecture: 'With the explosive growth of the last two decades in computer technology, one may ask well what lies ahead. The role of the prophet is not an easy one. In the first place, we are inclined to extrapolate into the future in a straight line, whereas science and technology tend to grow at an exponential rate. Thus our prophecies, more often than not, are far too conservative. In the second place, we prophesy from past trends. We cannot see the great and sudden mutations in scientific evolution. Thus we find ourselves predicting faster railroad cars and overlook the possibility of airplanes as being too fanciful' (Shannon 1962).
10. 'Net art' comes in a variety of forms with a broad range of intentions, encompassing everything from e-mail projects and websites to innovative Internet software and participatory networked art enterprises among users. It is an international movement that had its origins in Eastern Europe and is largely interactive. For an excellent history of the phenomenon, see: R. Greene (2004), *Internet Art*, London: Thames & Hudson.